



# Hospital-acquired infections in a tertiary hospital in Iran before and during the COVID-19 pandemic

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Received: 26 October 2021 / Accepted: 24 January 2022 / Published online: 7 March 2022  
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**Summary** Infection prevention protocols are the accepted standard to control nosocomial infections. These protective measures intensified after the coronavirus 2019 (COVID-19) pandemic to reduce the risk of viral transmission. It is the rationale that this practice reduces nosocomial infections. We evaluated the impact of these protective measures on nosocomial infections in our center with more than 20,000 records of annual patient admission. In a retrospective study, we evaluated the incidence of nosocomial infections in Sina hospital for 9 months (April–December 2020) during the COVID-19 period and compared it with the 8 months in the pre-COVID period (April–November 2019). Despite decreasing the number of admissions during the COVID era (hospitalizations showed a reduction of 43.79%), the total hospital nosocomial infections remained unchanged; 4.73% in the pre-COVID period versus 4.78% during the COVID period. During the COVID period the infection percentages increased in the cardiovascular care unit ( $p$ -value=0.002) and intensive care units ( $p$ -value=0.045), and declined in cardiology ( $p$ -value=0.046) and neurology ( $p$ -value=0.019) wards. This study showed that intensifying the infection prevention protocols is important in decreasing

the nosocomial infections in some wards (cardiology and neurology). Still, we saw increased nosocomial infection in some wards, e.g., the intensive care unit (ICU) and coronary care unit (CCU). Thus, enhanced infection prevention protocols implemented in hospitals to prevent the spread of a pandemic infection may not always decrease rates of other hospital-acquired infections during a pandemic. Due to limited resources, transfer of staff, and staff shortage due to quarantine measures may prohibit improved prevention procedures from effectively controlling nosocomial infections.

**Keywords** Nosocomial infections · Healthcare-associated infections infection prevention · Surgical site infections · Urinary tract infections · Bloodstream infection

## Abbreviations

BSI	Bloodstream infection
CCU	Coronary care unit
HAIs	Healthcare-associated infections
IPC	Infection prevention and control policies
IPD	International Patient Department
MDR	Multidrug resistance
PNEU	Pneumonia
PPE	Personnel protective equipment
SSI	Surgical site infection
UTI	Urinary tract infection
VAE	Ventilator-associated infections or events
VIP	Very Important Person

## Introduction

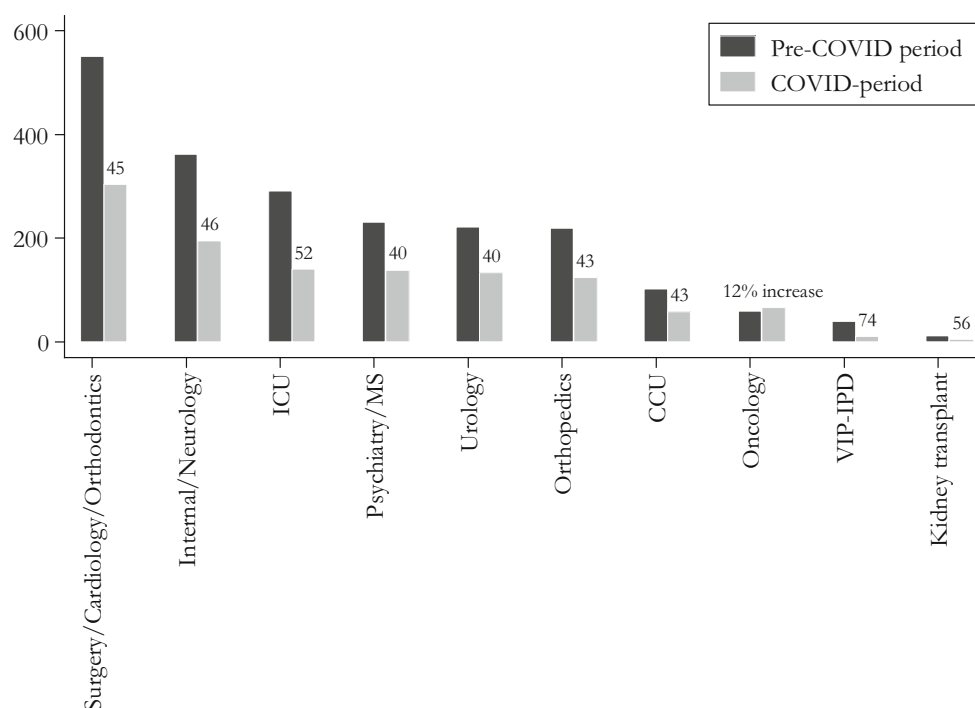
Since the beginning of the coronavirus disease 2019 (COVID-19) pandemic in early 2020, many protective measurements such as hand hygiene and Personnel Protective Equipment (PPE) have been employed to

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**Fig. 1** The monthly averages of hospitalizations comparing the before and during the pandemic and percentage of the change in hospitalization. *VIP* very important person, *IPD* international patient department, *CCU* coronary care unit, *ICU* intensive care unit



reduce the risk of infection transmission [1–3]. The rationale is that these protocols reduce other microbial spreads in many medical and surgical wards. World Health Organization (WHO) definition of Healthcare-Associated Infections (HAIs) is an infection acquired in the hospital by a patient admitted for a reason other than that infection. The different widely used definition presented by Benenson is “An infection occurring in a patient in a hospital or other health care facility in whom the infection was not present or incubating at the time of admission. These include infections acquired in the hospital but appearing after discharge, and occupational infections among the facility staff” [4–6].

They comprised ventilator-associated infections or events (VAE), pneumonia (PNEU), surgical site infection (SSI), bloodstream infection (BSI), and urinary tract infection (UTI). They have a significant economic burden on the health system, and any efforts to reduce them are appreciated [7–11]. The impact of protective measures in the COVID era on the prevalence of nosocomial infections is contradictory. Some studies reported decreasing the nosocomial infection in specific wards such as the neurologic ward, and others reported otherwise [12, 13]. Concerning these reports, we evaluated the role of protective measures on the incidence of nosocomial infection in our hospital during 9 months in the COVID period with 8 months in the pre-COVID era.

## Methods

This retrospective study utilized the hospital records of the patients hospitalized in the Sina University

Hospital, Tehran, documented in April–November 2019 and April–December 2020 after approval by the Ethics Committee of the Tehran University of Medical Sciences (IR. TUMS. SINA HOSPITAL.REC.1400.037). Our hospital is a large well-known referral hospital with more than 20 wards (e.g., vascular surgery, trauma, general surgery, neurosurgery, oncology, medical wards, two ICUs, one CCU, two urology wards, and one transplant ward). We documented more than 20,000 records of annual patient admissions. We gathered data with the active participation of our hospital infection control committee. The infection control committee consists of specialized nurses who check daily reports of routine cultures in the ward and follow lab data of any patient suspected of the different types of infections (urinary tract, surgical site, bloodstream) and recorded in the hospital infection registry system. The total cases of hospitalization and nosocomial infections were analyzed in two periods. Also, we analyzed different types of infections according to the source of infections in 2018, 2019, and the COVID era in 2020. The findings are presented as numbers and percentages and compared between two time periods using the proportion test. The categorical variables were compared between the periods using the  $\chi^2$  test. The analyses were performed using the statistical software Stata (ver. 13). The significance level was chosen as 0.05.

## Results

The total number of hospitalizations in the 8 months before COVID (April–November 2019) was 16,687; among them, 790 infections were recorded (4.73%).

**Table 1** Number of admissions before and during the COVID-19 pandemic by hospital ward

Unit	Before the pandemic	During the pandemic
CCU	102	58
Cardiology	197	121
ICU general	189	98
ICU emergency	53	21
ICU neurology	49	21
Internal men	95	46
Internal women	103	39
Orthodontics (maxillofacial)	87	24
Kidney transplant	11	5
Multiple Sclerosis	64	42
Neurology men	109	70
Neurology women	55	40
Oncology	59	66
Orthopedics men	104	64
Orthopedics women	115	60
Psychiatry men	93	54
Psychiatry women	74	42
Surgery	267	158
Urology	221	133
VIP-IPD	39	10

*VIP* very important person, *IPD* international patient department, *CCU* coronary care unit, *ICU* intensive care unit

Moreover, in the 9 months during COVID (April–December 2020), 10,553 hospitalizations and 504 infections were recorded (4.78%). The hospitalizations showed a total reduction of 43.79% (Fig. 1). We categorized surgical, medical, and intensive care cases for easy comparison; Cardiology, Surgery, and Jaw and Face, were in one category, the three ICUs were combined, the Internal and Neurology wards, Multiple Sclerosis and Psychiatry formed one group, and finally, Orthopedics were combined. The five wards, including CCU, Kidney transplant, Oncology, Urology, the Very Important Person (VIP)–International Patient Department (IPD), remained as before. Fig. 1 presents the reduction of hospitalizations. The number of hospitalizations declined in all wards, except for the Oncology ward, which showed an increase of 12.0%. The most reduction in the hospitalization was in the VIP and transplant ward (73.59 and 55.5%, respectively; Table 1).

The infection percentages are presented in Table 2, divided into the hospital’s 20 wards and comparing the two time periods. The infection percentages were compared using the proportion test, leading to the *p*-values reported in Fig. 2. The upper and lower panels depict the wards witnessing a decrease and increase in the infection percentages, respectively. The before/during percentages were compared using the proportion test, demonstrating significant increases in CCU, ICU general, and ICU urgency wards and declines in Cardiology and Neurology (both men and women) wards.

**Table 2** Hospital-acquired infection rates before and during the COVID-19 pandemic in percent of all admissions to these wards and units

Ward	Before COVID 2019 (%)	During COVID 2020 (%)	<i>p</i> -value
CCU	0.98	3.44	0.002
Cardiology	2.60	1.46	0.046
ICU general	18.42	21.78	0.045
ICU emergency	18.78	38.17	<0.001
ICU neurology	4.87	8.51	0.086
Internal men	6.29	7.00	0.636
Internal women	4.61	3.67	0.470
Orthodontics(maxillofacial)	2.45	0.93	0.171
Kidney transplant	15.91	15.91	1.000
Multiple sclerosis	0.39	0.80	0.428
Neurology men	2.65	0.96	0.019
Neurology women	6.18	3.05	0.039
Oncology	1.89	0.84	0.129
Orthopedics men	5.78	3.84	0.100
Orthopedics women	4.02	3.70	0.757
Psychiatry men	1.08	2.25	0.102
Psychiatry women	3.87	2.38	0.206
Surgery	2.20	2.75	0.302
Urology	0.68	0.84	0.621
VIP-IPD	3.19	3.23	0.988

*VIP* Very Important Person, *IPD* International Patient Department, *CCU* coronary care unit, *ICU* intensive care unit

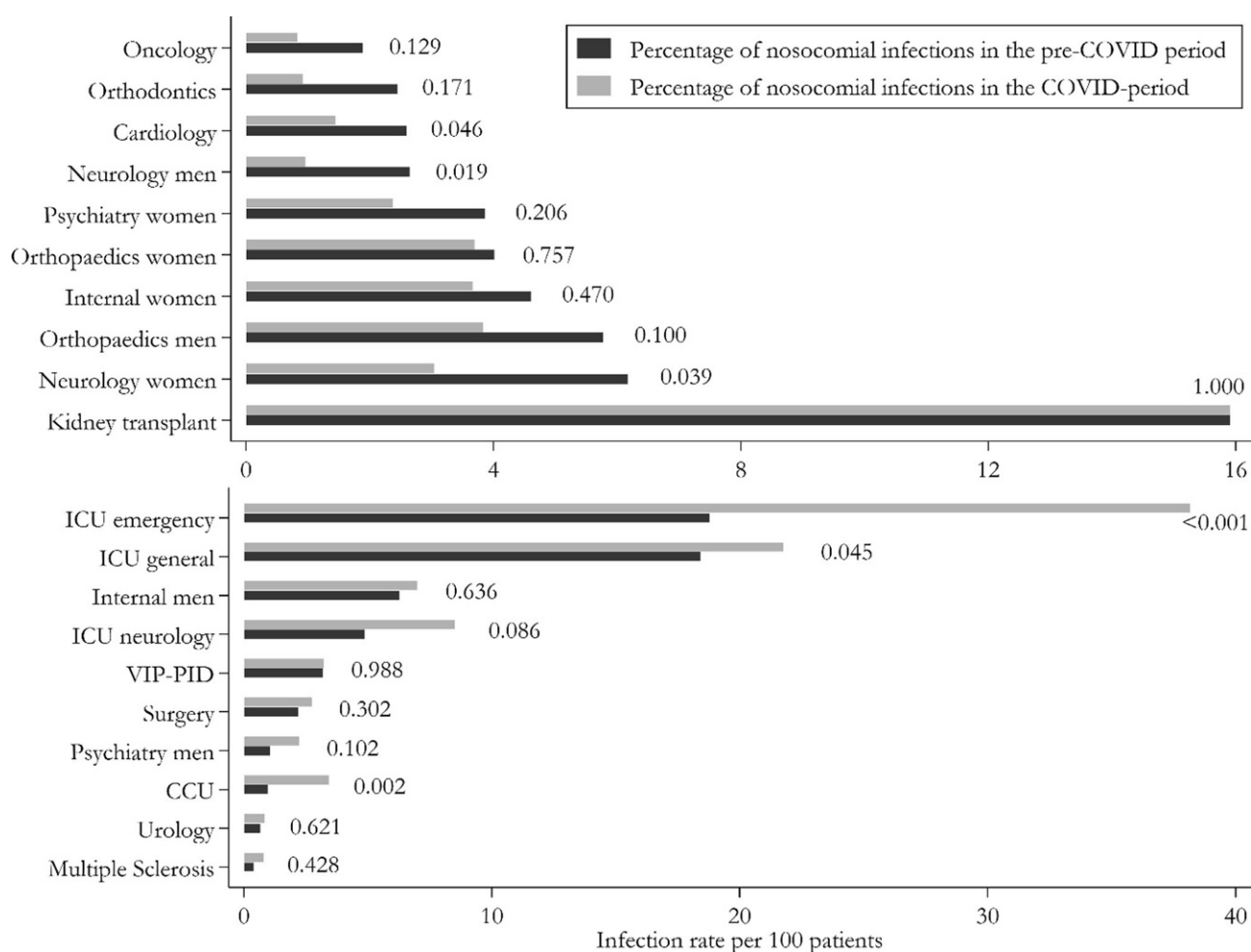
**Table 3** Hospital-acquired infections (HAIs) in the years 2018, 2019 and 2020, by type of HAI in percent of all HAIs and overall in percent of all admission in that year

Year	NI category						NI (%)
	VAE%	PNEU%	UTI%	BSI%	SSI%	Other%	
2018	24.0	1.22	39.6	10.4	23.5	1.2	5.9
2019	24.1	1.39	29.0	15.4	27.2	2.9	4.73
2020	35.9	0.47	18.6	22.8	17.5	4.7	4.78

*NI* nosocomial infection, *VAE* ventilator-associated events, *PNEU* pneumonia, *UTI* Urinary tract infection, *BSI* bloodstream infection, *SSI* surgical site infection

We also evaluated the total rate of nosocomial infection in 2018 separately. We compared it with the two mentioned periods in our study to ensure the complete performance of hospitals’ infection prevention control (IPC) policy one year before commencing COVID compared to 2018. The distribution is significantly different between the three years and every two subsequent years, as the  $X^2$  test shows (*p*-values < 0.001). The rate of pneumonia, UTI, and SSI decreased in COVID time compared with the same period in the pre-COVID era in 2019 (Table 3).

Finally, the microbial species distribution over the study periods is described in Table 4. We assessed a total of 4200 specimens during these periods. Some microbial species like *Acinetobacter* and *Klebsiella* in-



**Fig. 2** The hospital-acquired infection rate before and during the COVID-19 pandemic; numbers next to the bars are *p*-values comparing the two periods by  $\chi^2$  tests. *VIP* very important

person, *IPD* international patient department, *CCU* coronary care unit, *ICU* intensive care unit

creased during the COVID period compared to the pre-COVID period.

## Discussion

Nosocomial infections are a global problem. Many centers' have strategies, such as hygienic protocols, health providers' educational programs, and stewardship programs for preventing unnecessary antibiotics administration [14]. Hospital-associated infections (HAIs) have a tremendous economic burden on the health system [7, 15]. The main reason for nosocomial infections is improper antibiotic administration [16, 17]. Recent studies propose that hygienic protocols like frequent hand washing, personal protective equipment (PPE), and mask-wearing may reduce HAIs. In a survey by Irelli et al. they compared 216 patients who were admitted to the neurology ward in 2019 (pre-COVID era) with 103 patients in 2020 (COVID era) with regard to the incidence of hospital-associated infections (HAIs); their reports revealed a lower incidence of HAIs in 2020 compared

the 2019 period (23.3% versus 31.5%; *p*-value=0.01) [18]. In a contradictory study by Martinez et al., they evaluated the incidence of nosocomial endocarditis in the first 2 months after the start of the COVID-2019 pandemic and compared the incidence with the same period before the pandemic; they reported increases in the incidence of infective endocarditis as HAIs in the COVID era [13, 19]. In an exciting study by Alonso et al., they evaluated the incidence of clostridioides difficile infection in a 2-month period in 2020 with the same period in the pre-COVID era (2019); despite no reduction in the antibiotics prescription during COVID era incidence of HAIs clostridioides difficile infection decreased about 70%, which underscores the importance of hygienic protocols to reduce nosocomial infections [10, 20, 21].

Losurdo et al., in a cohort observational study, compared two sets of patients in the pre-COVID (418 patients) and the COVID era (123 patients) and reported a reduction of total, superficial and deep surgical site infections in the COVID era. They emphasize this concept that hygienic protocols like mask-wearing and

**Table 4** Microbial species identified in hospital-acquired infections during the study period before and during the COVID-19 pandemic

Species	Years		
	2018 (%)	2019 (%)	2020 (%)
<i>E. coli</i>	21.5	19	16.9
<i>Klebsiella pneumonia</i>	20.1	20.6	24.2
<i>Acinetobacter</i>	17.6	23.4	30.4
<i>Pseudomonas aeruginosa</i>	11.4	8.2	6.1
<i>Enterococcus faecalis</i>	6.6	8.2	6
<i>Staphylococcus aureus</i>	6.6	6.3	4.3
<i>Enterobacter</i>	3.7	3.1	3.5
<i>Candida albicans</i>	2.2	0	0
<i>Enterococcus faecium</i>	2.1	0.2	0.5
<i>Non-albicans Candida</i>	1.8	0	0
<i>Citrobacter freundii</i>	1.4	1.5	0.8
<i>Proteus mirabilis</i>	1.4	1.9	1.4
<i>Coagulase-negative staphylococci (CoNS)</i>	1.1	1.7	3.1
<i>Klebsiella oxytoca</i>	1	0.7	1.4
<i>Streptococcus agalactiae B</i>	0.3	0.4	0
<i>Unknown</i>	0.3	4.1	0
<i>Serratia</i>	0.2	0	0
<i>Staphylococcus saprophyticus</i>	0.2	0.1	0
<i>Burkholderia cepacia</i>	0.1	0.1	0
<i>Candida</i>	0.1	0.1	0
<i>Staphylococcus epidermidis</i>	0.1	0.1	0.2
<i>Streptococcus pneumoniae</i>	0.1	0	0
<i>Viridans streptococci</i>	0.1	0	0
<i>Group D streptococci</i>	0.1	0	0
<i>Alcaligenes faecalis</i>	0	0.1	0.5
<i>Clostridioides difficile</i>	0	0.1	0
<i>Clostridium perfringens</i>	0	0	0.3
<i>Salmonella paratyphi</i>	0	0	0.2
<i>Stenotrophomonas maltophilia</i>	0	0	0.2

restriction of visitors could reduce nosocomial infections. [22]. In the supporting recommendation for reinforcing the hygienic measures, Irelli et al. emphasize the adherence to hygienic protocols for preventing nosocomial infections even after ending this pandemic [23].

In a study by Bentivegna et al., they compared the incidence of multidrug resistance (MDR) organisms in the pre-COVID era and COVID time. They revealed that hygienic protocol significantly reduced the rate of MDR infections (29% vs. 19%) [24]. Cole et al. mentioned reducing multidrug resistance organisms such as staphylococcus aureus, extended-spectrum beta-lactamase, and vancomycin-resistant enterococcus incidence with protective measures like hand washing and mask-wearing in the COVID period compared with pre-COVID period about 41%, 21%, and 80%, respectively [25]. In a study by Lo et al., a collateral benefit of the COVID-19 prevention measures on the incidence density of multidrug-resistant

organisms (MDRO) was observed where the incidence of COVID-19 was low [26].

In an exciting study, Reuben et al. evaluated the impact of preventive measures for COVID-19 on reducing Lassa fever in Nigeria and revealed the reduction of Lassa fever cases in Nigeria due to the same route of transmission [27]. Wee et al. cited the reduction of adenovirus incidence in the COVID era compared to the pre-COVID era in their referral center in Singapore (0.03% vs. 0.4%). They cited that this reduction was observed only in nosocomial infection of the adenovirus. At the same time, the rate of community-acquired adenovirus infection increased, emphasizing the effect of preventive measures in hospital reduction of nosocomial adenovirus [28]. In another study in Singapore, the rate of respiratory viral infections, MRSA, and central venous line infections decreased in the COVID era compared to the pre-COVID period due to intensifying preventive measures [29].

Wong et al. demonstrated a reduction of viral influenza A and B during the COVID era compared to the pre-COVID era in their hospital, emphasizing infection prevention and control policies (IPC) such as face masks and hand washing on the reduction of nosocomial infections again [30]. In a study by Hu et al., they emphasized the face mask besides social distancing and hand washing and mentioned that this practice could reduce HAIs [31]. Wee et al. reported their experience in the hematologic ward. They concluded that preventive measures decrease respiratory viral infection during the COVID era compared to the pre-COVID era [32]. Jabarpour et al. studied the effect of preventive infection control for COVID-19 on HAIs. They reported a significant reduction of HAIs in ICU and medical-surgical wards, different from our results [33].

Points of this study are (a) despite reducing the admissions in our center, the percentage of infection remained unchanged in the COVID period compared to the pre-COVID period (4.78% vs. 4.73%). Most studies showed a decline in nosocomial infection rates in a different ward. However, in our referral center, the quality of IPC protocols was an optimum point, so IPC measures did not reduce nosocomial infections. (b) Nosocomial infections increased in the intensive units (CCU, ICUs) and declined in the cardiology and neurology wards; the other wards remained unchanged. It seems that there are factors that affect the rate of nosocomial infections (NI), such as the shortage of nurses in ICU, lack of compliance, and exhaustion of personnel due to prolonged and demanding working hours. Thus, it is crucial to support the workforces with fresh and skilled additional staff.

This finding was different from the other study that concluded a decrease of nosocomial infection in the intensive units was probably due to more preventive measures during the COVID era. Since COVID-19 was highly prevalent in Iran during the study period, the

transfer of staff to the infection wards and COVID-19 reserved ICUs led to a concomitant overload in the other wards and thereby to difficulties in adherence control measures. However, the quality of the IPC policies and implementation of the protocols in each medical center could affect the results, so we analyzed the nosocomial infection rate in three consecutive years. The changes in the NIs showed that the IPC protocols had successfully diminished the rate of nosocomial infection in 2019 comparing 2018 in our center, so it seems any study that compares these two periods should consider the quality of IPC as a confounding factor in the study.

## Conclusion

The adherence to the national guidelines of infection prevention and control (IPC) should be an ongoing program despite the persistence of COVID-19. In some wards like the ICU, we should consider the lack of compliance and exhaustion of personnel due to prolonged and tedious working hours. Thus, it is crucial to support the exhausted and overworked personnel with fresh and skilled additional staff during the pandemic.

**Acknowledgements** The authors would like to thank the Urology Research Center at Sina hospital.

**Funding** No funding was received.

## Declarations

**Conflict of interest** A. Mohammadi, F. Khatami, Z. Azimbeik, A. Khajavi, M. Aloosh and S.M.K. Aghamir declare that they have no competing interests.

**Ethical standards** The study was approved by the Ethics Committee of the Tehran University of Medical Sciences (IR.TUMS.SINA HOSPITAL.REC.1400.037).

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